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The prevalence, associated risk factors and pregnancy related outcomes of large for gestational age new-borns delivered at Chris Hani Baragwanath Academic Hospital

By Natsai Michelle Chibaya

Student number: 300191

October 2024

A research report submitted to the Faculty of Health Sciences, University of The Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Medicine in Obstetrics and Gynaecology

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DECLARATION

I Natsai Michelle Chibaya, hereby declare that this research paper is my original unaided work. It is being submitted for the degree of Master of Medicine in Obstetrics and Gynaecology, at the University of The Witwatersrand. I declare that this paper has not been submitted before to any other institution for assessment purposes. I have acknowledged all sources and cited these in the reference section. There are no conflicts of interest in creating this research paper.

This paper was prepared in a "submissible" format in line with the guidelines of the South African Journal of Obstetrics and Gynecology (SAJOG).

Signed on this day of 3rd of October 2024.



Natsai Michelle Chibaya

DECLARATION BY SUPERVISORS OF AUTHOR CONTRIBUTIONS

The following individuals contributed as supervisors to the work undertaken by the candidate, Natsai Michelle Chibaya, student number 300191, for the research paper titled "**The prevalence, associated risk factors and pregnancy related outcomes of large for gestational age new-borns delivered at Chris Hani Baragwanath Academic Hospital**", in partial fulfilment of the requirements for the degree of Master of Medicine in Obstetrics and Gynaecology.

Details of the supervisors:

- Supervisor 1: Natalie Odell
- Supervisor 2: Chrysanthi Georgiou
- Supervisor 3: Nadiya Frank

Contribution of work by the candidate and supervisors for the above-mentioned research paper:

- The research paper is the original work of the candidate, Natsai Michelle Chibaya, who drafted the protocol, collected all data and drafted the final research paper for this study.
- The supervisors critically reviewed all drafted manuscripts, of the protocol and the final research paper, supervised data collection and guided the research methodology, made improvements to content, and guided the general conduct, and conceptual ideas.
- All authors approved the final manuscript.
- This proposal and the research paper were submitted to Turnitin concerning plagiarism.
- The plagiarism certificates were checked and are satisfactory.

Signed on this day 3rd of October 2024





Natalie Odell	Chrysanthi Georgiou	Nadiya Frank

DEDICATION

I dedicate this work to my God, my late mother, Sekai, my son Nduduzo and my family for always being the light that shines through the darkness.

ACKNOWLEDGEMENTS

I would like to thank and acknowledge my supervisors Dr Odell, Dr Georgiou and Dr Frank for helping me develop and complete this project, with so much support and ease. I would also like to thank and acknowledge Dr Admire Chikandiwa for setting up the RedCAP data collection sheet and data analysis. I also give great thanks to the staff at Chris Hani Baragwanath Academic Hospital Obstetric Unit for allowing and facilitating the study.

Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

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Data availability

The data that supports the findings of our study are not openly available due to the sensitivity of human data, and are available from the candidate and author, Natsai Michelle Chibaya, upon reasonable request.

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JOURNAL PUBLICATION

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Available at: https://samajournals.co.za/index.php/sajog

TABLE OF CONTENTS

DECLARATION……...……..……... i

DECLARATION BY SUPERVISORS OF AUTHOR CONTRIBUTIONS……..……..... ii

DEDICATION……...……..…. iii

ACKNOWLEDGEMENTS……..……..……. iv

JOURNAL PUBLICATION……...……..……....v

TABLE OF CONTENTS ……..……...…vi

LIST OF ABBREVIATIONS……...……..… vii

AUTHOR GUIDELINES FOR SAJOG……..……. viii

SUBMISSIBLE ARTICLE

TITLE AND AUTHORS…….……..... 1

ABSTRACT…….…….. 2

INTRODUCTION……..…….……... 3

METHODS……4

RESULTS……..…… 5

TABLE 1: Maternal outcomes and complications……..…….....6

TABLE 2: Fetal and Neonatal outcomes……..……..……7

TABLE 3: Factors and outcomes associated with LGA birthweights ≥ 4 000g vs birthweights < 4 000g…….…...8

GRAPH 1: Distrubution of LGA babies according to gestation……9

GRAPH 2: Distrubution of LGA babies according to centiles……9

DISCUSSION…….....10

CONCLUSION……... …….13

REFERENCES……15

APPENDICES

Appendix 1: APPROVED PROTOCOL……...18

Appendix 2: DATA COLLECTION SHEET…….....31

Appendix 3: INTERGROWTH-21ST BOYS NEWBORN SIZE STANDARDS……..36

Appendix 4: INTERGROWTH-21ST GIRLS NEWBORN SIZE STANDARDS….....38

Appendix 5: GAIA TABLE……..40

Appendix 6: POSTGRADUATE APPROVAL OF TITLE LETTER……...41

Appendix 7: INSTITUTION PERMISSION TO CONDUCT RESEARCH…….....42

Appendix 8: ETHICS CLEARANCE CERTIFICATE……45

Appendix 9: SIMILARITY TURNITIN REPORT……...…46

Appendix 10: PLAGIARISM DECLARATION……..50

LIST OF ABBREVIATIONS

ACOG	American College of Obstetricians and Gynaecologists
BMI	Body mass index
CD4	CD4 lymphocyte count
CHBAH	Chris Hani Baragwanath Academic Hospital
G	Grams
GAIA	The Global Alignment of Immunization safety Assessment in Pregnancy
HB	Haemoglobin
HREC	Human Research Ethics Committee
HIV	Human immunodeficiency virus
ICU	Intensive Care Unit
ID	Identification
KG	Kilograms
LGA	Large for gestational age
LNMP	Last normal menstrual period
M	Metre
NICU	Neonatal intensive care unit
NND	Neonatal death
OGTT	Oral glucose tolerance test
RDS	Respiratory distress syndrome
RH	Rhesus factor
RPR	Rapid plasma regain
SAJOG	South African Journal of Obstetrics and Gynaecology
SD	Standard deviation
WHO	World Health Organization

AUTHOR GUIDELINES FOR SAJOG

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  - Legal references
    - Government Gazettes:
      National Department of Health, South Africa. National Policy for Health Act, 1990 (Act No. 116 of 1990). Free primary health care services. Government Gazette No. 17507:1514. 1996.
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    - Acts:
      South Africa. National Health Act No. 61 of 2003.
    - Regulations to an Act:
      South Africa. National Health Act of 2003. Regulations: Rendering of clinical forensic medicine services. Government Gazette No. 35099, 2012. (Published under Government Notice R176).

- Bills:

  South Africa. Traditional Health Practitioners Bill, No. B66B-2003, 2006.
- Green/white papers:

  South Africa. Department of Health Green Paper: National Health Insurance in South Africa. 2011.
- Case law:

  Rex v Jopp and Another 1949 (4) SA 11 (N)

  Rex v Jopp and Another: Name of the parties concerned

  1949: Date of decision (or when the case was heard)

  (4): Volume number
- SA: SA Law Reports

  11: Page or section number

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SUBMISSIBLE ARTICLE

The prevalence, associated risk factors and pregnancy related outcomes of large for gestational age new-borns delivered at Chris Hani Baragwanath Academic Hospital

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ABSTRACT

Background. Large for gestational age (LGA) refers to a newborn birthweight equal to or greater than the 90th percentile for a given gestational age. Delivering an LGA newborn poses a high risk of morbidity and mortality for both mother and baby.

Objectives. To describe the prevalence of term LGA newborns and identify the factors and pregnancy-related outcomes associated with delivering term LGA newborns at Chris Hani Baragwanath Academic Hospital (CHBAH), a tertiary hospital in Johannesburg, South Africa.

Methods. This was a retrospective, institution-based cross-sectional study from 1 October 2020 to 31 March 2021, in which 275 LGA singleton-term newborn deliveries were reviewed. Patient demographics, medical factors and clinical outcomes were recorded and statistically analysed.

Results. The prevalence of LGA newborns in singleton-term deliveries at CHBAH was found to be 3.92%. The associated factors included maternal obesity, multiparity, prolonged pregnancy with a gestational age greater than 40 weeks, a mother's history of previously birthing an LGA infant and male newborn gender. The maternal complications observed included prolonged labour, increased caesarean delivery, postpartum haemorrhage, obstetric anal sphincter injuries and uterine rupture. The fetal and neonatal complications included shoulder dystocia, neonatal hypoglycaemia, and neonatal respiratory distress syndrome.

Conclusions. LGA singleton-term newborn deliveries at CHBAH were associated with both maternal and neonatal morbidity. The presence of associated factors should alert maternity caregivers to closely monitor these pregnancies and plan for an appropriate mode of delivery. Newborns that are LGA should be routinely screened and appropriately managed for hypoglycaemia.

INTRODUCTION

A baby's birthweight is an important factor which decisively affects and predicts an infant's survival and is also correlated with future health outcomes during adolescence and adulthood.[1] For babies born with larger birthweights, instituting an invariably recognised definition across the world has been difficult.[2] As described by The American College of Obstetricians and Gynaecologists (ACOG), a term that can be used when describing excessive fetal growth is "large for gestational age".[2] Large for gestational age (LGA) refers to a birthweight equal to or greater than the 90th percentile for a given gestational age.[2]

The risk factors for birthing LGA babies can be categorised into maternal and fetal. Maternal risk factors include maternal diabetes, high maternal pre-pregnancy weight, disproportionate maternal weight gain during pregnancy, advanced maternal age, multiparity, post-term pregnancy, maternal birthweight greater than 4 000g and the previous birth of an LGA newborn. [2,3,4,5] Fetal risk factors include familial traits, male gender, and genetic variants and syndromes. [2,4]

Maternal complications of LGA births include protracted labour, need for assisted vaginal delivery, genital tract lacerations, postpartum haemorrhage, caesarean section delivery and uterine rupture which could lead to both maternal and fetal mortality.[6,7] Fetal complications include shoulder dystocia resulting in birth traumas such as brachial plexus injuries, fractures or in the worst case, asphyxia.[4,6,7] In utero, larger babies are at risk of stillbirth and neonatal complications include hypoglycaemia, respiratory problems, polycythaemia and increased frequency of neonatal admission to an intensive care unit.[4,6,8] When looking at childhood and beyond, the most common complications described are obesity, impaired glucose tolerance and metabolic syndromes.[9] In developing countries, there has been an increase in mothers delivering LGA newborns, which is a great public health concern due to the high risk of morbidity and mortality for both mother and baby.[10] Although the incidence is on the rise, there is still limited research on this topic in our setting, which was the drive for our study.

METHODS

A retrospective, institution-based and cross-sectional observational study, was conducted from 1 October 2020 to 31 March 2021 at Chris Hani Baragwanath Academic Hospital (CHBAH) Obstetric Department. CHBAH is an academic and tertiary hospital located in Soweto, in Johannesburg, South Africa.[11] It is the largest hospital in Africa and performs between 20 000 to 25 000 deliveries per annum.[11] All women who delivered an LGA newborn from a singleton-term pregnancy at CHBAH during the study period were included. LGA in this study was defined as a birthweight equal to or greater than the 90th percentile for a given gestational age, using birthweight percentile references from INTERGROWTH-21st resources, for males and females.[12] A term pregnancy for this study included deliveries occurring from 37 0/7 weeks of gestation through to 42 0/7 weeks of gestation. Multiple pregnancies were excluded.

The birth registers were reviewed for all births during the study period. Mothers who delivered LGA newborns from a singleton-term pregnancy were identified and their maternity records were assessed. The ACOG gestational age calculator was used when combining gestational age assessments from the last normal menstrual period (LNMP) with those extrapolated from ultrasonography to accurately determine the gestational age. [13] Additionally, the total number of deliveries over the study period was identified, to determine the prevalence of LGA births from singleton-term deliveries. All mothers included in the study were allocated a study identification (ID) number, which correlated with the respective hospital numbers found in the birth registers. All the relevant data from the maternity records were recorded on a datasheet in RedCAP and included participant demographics, obstetric factors, medical factors, maternal and neonatal-related factors, and pregnancy outcomes. [14] There was no identifying information included on the data collection sheet. All data were collected by the principal investigator.

Frequencies and percentages were used to describe categorical data. The Shapiro-Wilk test was used to test for the normality of continuous variables. Normally distributed data were then presented as mean and standard deviation (SD) whilst non-parametric data were summarized with medians and inter-quartile range (IQR). The main outcome variable of neonatal LGA birthweight was further divided into a dichotomous variable (i.e., 1= LGA newborns with a birthweight ≥ 4 000g and 0 = LGA newborns with a birthweight < 4 000g). ACOG describes a baby born with a birthweight of 4 000g or greater as fetal macrosomia.[2] This further analysis was done to assess if the addition of macrosomia to LGA had an impact on maternal and fetal

outcomes in our study. Multivariate logistic regression models were computed to estimate the association between various maternal and neonatal factors and those LGA newborns with a birthweight of ≥ 4 000g. An adjustment was done for risk factors that had a p-value of < 0.1 at univariate analysis to identify factors independently associated with LGA birthweights of ≥ 4 000g. All data analyses were conducted in Stata 15.0®. (StataCorp, 4905 Lakeway Drive, College Station, Texas 77845 USA). A p-value < 0.05 was considered statistically significant for LGA birthweights of ≥ 4 000g.

Before commencing the study, ethical approval was obtained from The University of the Witwatersrand Human Research Ethics Committee (HREC) (Medical), with a clearance certificate number M2111119. Institutional permission was obtained from the Chief Executive Officer of CHBAH, the medical advisory committee of CHBAH and the Head of the Department of the Obstetrics and Gynaecology unit at CHBAH.

RESULTS

There was a total of 7010 singleton-term deliveries at CHBAH during the six-month study period, and 275 newborn babies were identified to be large for gestational age. These were the 275 study participants included in our study, none of the eligible deliveries were excluded from the study.

Participant demographics

The mothers' ages ranged from 14 to 50 years old, with a mean age of 29.4 (±6.1) years. Concerning parity, 54 (19.6%) mothers were primigravida and 221 (80.4%) mothers were at least pregnant for the second time during the study pregnancy. The average maternal weight at the first antenatal visit was 83.9 (±18.6) kilograms (kgs), with an average maternal body mass index (BMI) at the first visit of 32.7kg/m2 (±7.2), which is classified as obese.[13] Only 36 (13.4%) mothers had a normal weight, and 40 (14.9%) mothers were morbidly obese.[13]
Seven (2.5%) mothers had pre-existing diabetes mellitus, and 7 (2.5%) mothers had gestational diabetes mellitus. Forty-nine (17.8%) mothers had a history of previously delivering an LGA baby and 8 (2.9%) mothers had previously delivered a stillborn. Forty-three (15.6%) mothers were HIV positive. The mean haemoglobin at the first antenatal visit was 11.9 with an interquartile range of 11.0 to 13.0

Maternal outcomes and complications

Maternal outcomes and complications are shown in Table 1. Two-hundred and fifty-seven mothers went into labour, and half, 134 (52.1%) of these deliveries were complicated by prolonged labour. The overall caesarean section rate in the group was 45.1%. All emergency caesarean sections were performed on mothers, who were already in labour. Eighty-three (30.2%) mothers suffered obstetric anal sphincter injuries. Four (1.5%) deliveries were complicated by uterine rupture.

Table 1: Maternal outcomes and complications (n = 275)

Description	**n (%)**
Normal vaginal delivery	143 (52.0)
Assisted vaginal delivery	8 (2.9)
Caesarean delivery	124 (45.1)
Type of caesarean delivery:	
Emergency	106 (38.5)
Elective	18 (6.6)
Emergency caesarean delivery indications:	
Fetal distress	39 (14.2)
Obstructed labour	38 (13.8)
Previous caesarean, declining trial of labour	22 (8.0)
Other	7 (2.5)
Elective caesarean delivery indications:	
Previous caesarean delivery	14 (5.1)
Other	4 (1.5)
Prolonged labour (n = 257)	134 (52.1)
Postpartum haemorrhage	16 (5.8)
Perineal tears	83 (30.2)
Degree of perineal tear (n = 83):	

1st 2nd 3rd 4th	37 (44.6) 44 (53.0) 1 (1.2) 1 (1.2)
Uterine rupture	4 (1.5)
Maternal death	0 (0)

Fetal and Neonatal outcomes

Fetal and neonatal outcomes are shown in Table 2. The majority, 270 (98.2%) babies were born alive and there were 5 stillbirths. Amongst the stillbirths, 3 deliveries were normal vaginal births, and the other 2 were by caesarean section, 3 babies were born macerated implying antenatal fetal demise and there were 2 fresh stillbirths suggestive of intrapartum fetal demise. Both fresh stillbirths occurred in mothers who had deliveries complicated by uterine rupture. One stillborn had features suggestive of a congenital abnormality and one mother who birthed a stillborn had pre-gestational diabetes mellitus. Ten (7.0%) deliveries were complicated with shoulder dystocia and 5 of these deliveries were further complicated with neonatal birth trauma. Irrespective of the mode of delivery, half (49.1%) of the babies in the study group had complications immediately after birth that required admission. The most common neonatal complication observed was hypoglycaemia (32.7%). None of the babies were admitted for maternal reasons or maternal incapacity.

Table 2: Fetal and Neonatal outcomes (n =275)

Description	**n (%)**
Live Births Stillbirths	270 (98.2) 5 (1.8)
Should dystocia (n = 143)	10 (7.0)
Resuscitation at birth	20 (7.3)
Admission to the Neonatal Ward	135 (49.1)
Neonates with complications Neonates with more than one complication	135 (49.1) 22 (8.0)
Types of neonatal complications:	

Birth trauma	5 (1.8)
Birth asphyxia	9 (3.3)
Respiratory distress syndrome	40 (14.5)
Hypoglycaemia	90 (32.7)
Other	13 (4.7)
Neonatal deaths in the first 24 hours of life	0 (0.0)

Factors and outcomes associated with LGA birthweights of 4 000g or greater

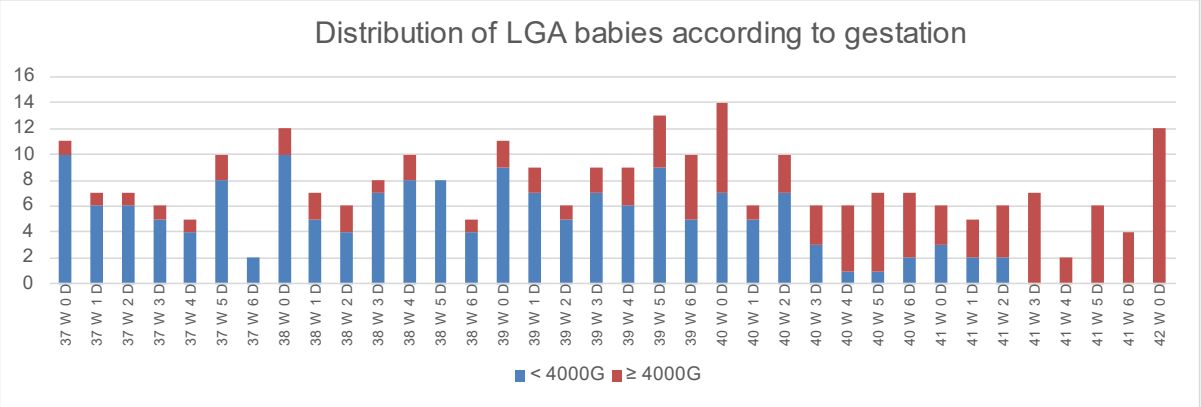
Data analysis revealed highly statistically significant factors and outcomes, at a p-value less than 0.05, associated with LGA newborns with birthweights of 4 000g or greater in comparison to LGA newborns whose birthweights were less than 4 000g. This is shown in Table 3.

Table 3: Factors and outcomes associated with LGA birthweights ≥ 4 000g vs birthweights < 4 000g (n = 275)

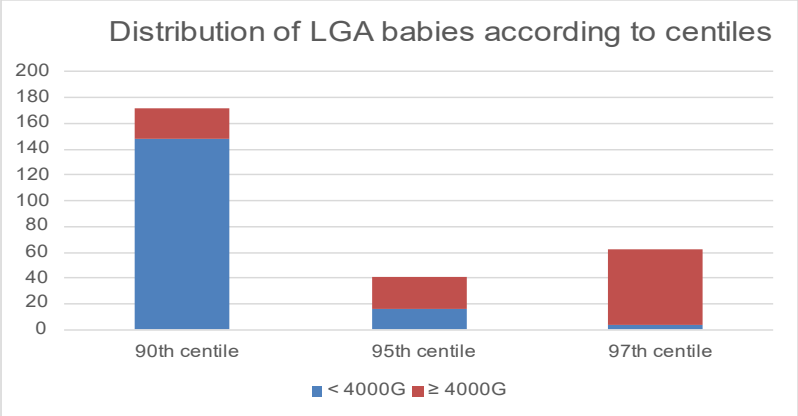
Description	**LGA < 4 000g n = 168 (%)**	**LGA ≥ 4 000g n = 107 (%)**	**P-value***	**Adjusted Odds Ratio**	**P-value***
Maternal BMI at booking (kg/m2) (n = 268):[15]	n = 162	n = 106			
Normal	28 (17.3)	8 (7.6)		1	
Overweight	38 (23.5)	25 (23.6)	0.08	2.18(0.78-6.27)	0.15
Obesity Class I	41 (25.3)	32 (30.2)	0.03	2.57 (0.90-7.36)	0.08
Obesity Class II	31 (19.1)	25 (23.6)	0.03	4.34 (1.40-13.44)	**0.01**
Obesity Class III	24 (14.8)	16 (15.1)	0.10	1.87 (0.60-5.88)	0.28
Maternal previous LGA birthweight ≥ 4 000g (recorded in antenatal card)					
No	146 (86.9)	80 (74.8)		1	
Yes	22 (13.1)	27 (25.2)	**0.01**	2.21 (1.07-4.55)	**0.03**

Gestational at delivery: Less than 40 weeks More than 40 weeks	 163 (97.1) 5 (2.9)	 73 (68.2) 34 (31.8)	 **0.0001**	 1 16.9 (5.8-49.3)	 **0.001**
Postpartum haemorrhage	6 (3.6)	10 (9.4)	0.06	6.02 (1.50-24.11)	**0.01**
Newborn Gender: Female Male	 86 (51.2) 82 (48.8)	 38 (35.5) 69 (64.5)	 **0.01**	 1 2.17 (1.23-3.82)	 **0.01**
Admission to the Neonatal Ward	53 (31.7)	82 (76.6)	**0.001**	10.75 (5.56-20.75)	**0.001**
Any neonatal complications	52 (31.1)	83 (78.3)	**0.001**	12.65 (6.41-24.99)	**0.001**
Neonatal Hypoglycaemia	14 (8.3)	76 (71.0)	**0.001**	40.19 (17.01-94.94)	**0.001**

Graph 1: Distribution of LGA babies according to gestation



Graph 2: Distribution of LGA babies according to centiles



DISCUSSION

The Prevalence

The prevalence of LGA deliveries in singleton-term newborns at CHBAH was found to be 3.92%. This finding was much lower than studies conducted in Italy, Qatar, and other Asian countries where the prevalence was reported to be 10% to 15.6%.[16,17,18] It is important to note that our study was conducted in a developing African country and thus this discrepancy may be attributed to variances in the characteristics of our study population, such as ethnic origins, race, and dietary habits and differences in the socio-economic status. Other probable reasons include the study time and variations in healthcare service systems. The study stillbirth rate was 18 per 1000 deliveries, which is similar to the South African stillbirth rate, reported in the Saving Babies Report, for infants weighing 500g or more.[19]

Associated factors

Our study identified that as the LGA newborn birthweight increased, there was also an associated increase in morbidity for both the mother and the baby, with statistically significant factors and pregnancy outcomes observed in LGA newborn birthweights that reached and exceeded 4 000g. Historically, irrespective of gestational age, ACOG describes this as fetal macrosomia.[2] Maternal diabetes, maternal obesity, and excessive weight gain in pregnancy have been identified as independent predictors of high neonatal birthweight in a study done by Alberico et al; as these conditions encourage a greater nutrient load to the fetus.[5] Approximately, nine out of ten (87.9%) of our study participants were overweight at their first antenatal visit, with a mean maternal weight of 83.9kg. The mean maternal BMI at booking was 32.7kg/m2, which is classified as obese.[15] Almost all the mothers (97.8%) in our study were overweight by the time they delivered, suggestive of significant weight gain during the study pregnancy. Furthermore, our study identified that maternal obesity was a risk factor for birthing a macrosomic LGA newborn, with an odds ratio of 4.34.

The prevalence of maternal diabetes (5.1%) in our study, was lower in comparison to a stronger relationship between maternal diabetes mellitus and LGA births, described by other authors.[2,5] A possible contributing factor is that CHBAH has a highly advanced obstetric diabetic unit,

and thus this finding may reflect adequate glycaemic control in their diabetic mothers and consequently, the diabetic mothers were not birthing LGA infants.[20] The fourteen diabetic mothers in our study did not have recent or last recorded HBA1c% values in their maternity records, hence we were unable to assess glycaemic control in these patients. Additionally, most of our study participants had no record of an oral glucose tolerance test (OGTT) in their maternity records; thus, it is possible that some of the pregnant mothers with abnormalities in glucose tolerance may have been missed, and not recognised as diabetic.

Prolonged pregnancy with a gestational age greater than 40 weeks, with an odds ratio of 16.9, further increases the chances of LGA newborns being complicated by macrosomia. The assumption is that prolongation of pregnancy may increase the period of fetal exposure to larger amounts of glucose and other maternal nutrients.[21] Thus, the early delivery before 40 weeks of gestation, customarily practised in the care of diabetic mothers may be another contributing factor to the low association of macrosomic LGA births with diabetic mothers seen in our study.

Multiparity was observed in 80.4 % of mothers who participated in our study. The hypothesis is that with increasing parity, there is a natural increase in maternal age, which in turn is accompanied by a decreased maternal insulin sensitivity, which results in higher glucose levels available for placental glucose transport.[21] Subsequently, the fetus is exposed to higher glucose levels and thus a greater deposition of adipose tissue in the fetus is seen.[21] In our study, a mother with a history of previously birthing a macrosomic LGA infant was twice as likely to birth another macrosomic LGA newborn ((odds ratio =2.21 (95% CI (1.07-4.55)), this eludes that familial traits and genetic variants are associated with these births; which are all known factors associated with LGA births.[2,4]

Male gender is a well-described fetal risk factor for being a larger infant at birth.[2,16] In our study, there was no significant difference when comparing the proportions of LGA male births with the proportions of LGA female births, and this could be due to chance. However, the study did observe that male LGA babies had a two times greater probability of becoming macrosomic compared to female LGA babies ((odds ratio=2.17 (95% CI (1.23-3.82)). This may be due to sexual dimorphism for metabolic hormones and factors such as insulin, insulin-like growth factors, growth hormones and inflammatory cytokines, found in the male sex.[21]

Maternal outcomes

The caesarean section rate in our study was 45.1%, which is twice as high as the global caesarean section rate and more than 1.5 times higher than the South African caesarean section rate.[22,23] This puts mothers delivering LGA infants at a greater risk of developing caesarean surgery-related complications.[24] The most common indications for caesarean delivery in our study were fetal distress, obstructed labour and previous caesarean scar. Many of the caesarean deliveries were emergencies, which additionally carry a greater risk for complications for both mother and baby, compared to scheduled caesarean deliveries. This highlights a need for early identification of mothers carrying LGA infants in the antenatal and intrapartum period, with an appropriate determination of the mode of delivery before labour ensues, thus mitigating delivery complications.

Half (48.7%) of the mothers in our study had prolonged labour [25] and one-third (30.2%) of mothers suffered obstetric anal sphincter injuries during vaginal delivery. These are common complications of delivering larger infants, and similar findings have been described by other authors. [6,7,26] Our study observed that the larger the birthweight, the greater the risk of postpartum haemorrhage, as the mothers who delivered macrosomic LGA newborns had a six times greater risk of complicating with postpartum haemorrhage ((odds ratio=6.02, 95% CI (1.50-24.11)). This increased risk of postpartum haemorrhage may be attributed to perineal tears and prolonged labour resulting in uterine atony.[26] Additionally, four deliveries in our study were complicated by uterine rupture, all four mothers had prolonged labour with features of obstruction, two of these mothers had a previous caesarean uterine scar and none of these mothers had received therapy for labour induction or augmentation. Therefore, uterine rupture can also be considered a cause of postpartum haemorrhage in our study.

Fetal and Neonatal Outcomes

Ten mothers (7.0%) in our study experienced a delivery complicated by shoulder dystocia, this incidence is higher than the incidence of 0.5-1% of shoulder dystocia during vaginal deliveries described by Deneux-Tharaux et al.[27] This in turn highlights the need for midwives and obstetricians facilitating vaginal deliveries in mothers suspected to be birthing LGA newborns to be appropriately trained in the emergency management of shoulder dystocia. Half (49.1%) of the LGA newborns had some form of neonatal complication that required neonatal hospital

admission after birth, and the risk of these complications increased as the LGA birthweight increased, as seen with the macrosomic LGA babies ((odds ratio=12.65, 95 % CI (6.41-24.99)).

Hypoglycaemia occurred in one-third (32.7%) of newborns, which is almost 3 to 6 times greater than the prevalence of transient hypoglycaemia reported in newborns.[28] Additionally, macrosomic LGA newborns had an odds ratio of 40.19 for hypoglycaemic complications. The proposition is that larger babies have been exposed to higher levels of maternal glucose, which results in fetal hyperinsulinemia, which in turn drastically lowers blood glucose in the newborn, once the maternal high glucose levels have been cut off after delivery.[4] With the low prevalence of maternal diabetes mellitus observed in our study, it is a concern that possibly some mothers were undiagnosed diabetics and the prevalence may be underestimated. This suggests that LGA newborns need close monitoring of their glucose levels regardless of whether the mother is recorded to be diabetic or not. Respiratory distress syndrome (RDS) was the second most common neonatal complication observed and it is hypothesised that RDS may occur due to the previously described fetal hyperinsulinemia decreasing the production of surfactant in the fetal lungs; thus, pulmonary maturation may falter until later in the pregnancy gestation.[4]

Study limitations

Our study was observational and as a single-group study, it was missing a direct, concurrent, comparison group with mothers who delivered appropriate for gestational-age newborns at CHBAH during the study period. Most of our study participants had no record of an oral glucose tolerance test (OGTT) in their maternity records; thus, it is possible that some of the pregnant mothers with abnormalities in glucose tolerance may have been missed, and not recognised as diabetic. Lastly, our study was of a much shorter duration, compared to other international studies.

CONCLUSION

The prevalence of LGA newborns in singleton-term deliveries at CHBAH was found to be 3.92%. The associated factors included maternal obesity, multiparity, prolonged pregnancy with a gestational age greater than 40 weeks, a mother's history of previously birthing an LGA infant and male newborn gender. The maternal complications observed included prolonged

labour, increased caesarean delivery, postpartum haemorrhage, obstetric anal sphincter injuries and uterine rupture. The fetal and neonatal complications included shoulder dystocia, neonatal hypoglycaemia, and neonatal respiratory distress syndrome. We recommend mandatory OGTTs for all overweight pregnant mothers and we advise that mothers carrying LGA babies be managed as high-risk during delivery, with a clear plan for mode of delivery and aftercare. We advise that LGA newborns should be routinely screened and appropriately managed for neonatal hypoglycaemia. Additionally, we advise the referral of all mothers who birthed a macrosomic LGA infant, to perform an OGTT six weeks postpartum, as this was not routinely done. For further study, we recommend a study with a controlled comparison group, in our clinical setting comparing LGA newborn deliveries with appropriate for gestational-age newborn deliveries at CHBAH, and for such a study to be performed over a period of years.

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Appendix 1: APPROVED PROTOCOL

EXECUTIVE SUMMARY

Background: Large for gestational age refers to a birth weight equal to or greater than the 90th percentile for a given gestational age. The incidence of delivering large for gestational age new-borns in sub- Saharan Africa is on the rise and is a great public health concern due to the associated increased morbidity and mortality for both mother and baby.

Aims: The study aims to describe the prevalence, related risk factors and pregnancy outcomes associated with delivering large for gestational age new-borns in the region of Johannesburg, in The Gauteng Province of South Africa.

Methodology: The study is a retrospective, intuition-based cross-sectional study, to be conducted at Chris Hani Baragwanath Academic Hospital. A retrospective review of all the birth records and maternal records will be done, for a period from the 1st of October 2020 to the 31st of March 2021. Detailed clinical and demographic information, and maternal and neonatal outcomes will be collected and interpreted.

Expected outcomes: The study expects to identify the prevalence of delivering large for gestational age infants in our region and compare this prevalence with other developing and industrial countries. The study expects to describe associated risk factors such as greater maternal pre-pregnancy weight, advanced maternal age, multiparity, presence of diabetes mellitus, prolonged pregnancy, previous history of a large for gestational age infant and excessive weight gain in pregnancy to be associated with the delivery of large for gestational age new-borns. The study expects to describe maternal and neonatal complications associated with these deliveries, such as postpartum haemorrhage, perineal tears and prolonged labour, birth asphyxia, shoulder dystocia, hypoglycaemia and perinatal trauma.

1. LITERATURE REVIEW

1.1 Introduction

A baby's birth weight is an important factor which decisively affects and predicts an infant's survival and is also correlated with future health outcomes during adolescence and adulthood.[1] At a population level, the mean birth weight of that particular population corresponds with the infant mortality rate for that population.[1] Infant mortality rate has been conventionally used

as a reliable evaluation of a population's health.[2] It is therefore important for researchers to fully understand the variables associated with the epidemiology of infant birth weight, in both extremes, for smaller and larger birth weights.

1.2 Definitions

For babies born with larger birth weights, instituting an invariably recognised definition for macrosomia across the world has been difficult.[3] As described by The American College of Obstetricians and Gynaecologists (ACOG), two terms can be practically used when describing excessive fetal growth; “large for gestational age” and “macrosomia”.[3] Large for gestational age (LGA) refers to a birth weight equal to or greater than the 90th percentile for a given gestational age. The term macrosomia indicates fetal growth that supersedes a birth weight, customarily of 4000g or 4500g, irrespective of the specific gestational age.[3]

1.3 Prevalence

The worldwide prevalence of birthing infants weighing 4000g or greater is approximately 9% and approximately 0.1% for birth weights of 5000g or greater.[4] There are however wide variations among different countries, populations, and ethnicities.[4] In the United States of America, approximately 7% of live-born infants weigh 4000g or more and 1% weigh more than 4500g.[5] The prevalence of birth weights of 4000g or greater in low-income countries is characteristically between 1 to 5% but ranges from 0.5 to 14.9%.[6]

1.4 Pathogenesis

While the exact processes that regulate fetal weight gain and overgrowth are unknown, extreme fetal growth seems to be a result of excessive delivery of nutrients to the fetus.[7] This is in turn influenced by both genetic factors and intrauterine environmental factors.[7] In a study looking at weight gain in pregnancy and the risk of maternal hyperglycaemia, it was noted that a large contributing factor to macrosomia was recurrent hyperglycaemia, in both maternal and fetal circulation.[8] This has been shown in the increased prevalence of fetal macrosomia in diabetic mothers.[3] The identified pathophysiology is that with intermittent fetal hyperglycaemia, there is an increased release of insulin, growth hormone and insulin-like growth factors, which subsequently leads to large deposits of fat, especially into fetal subcutaneous tissues, and ultimately enhances and increases fetal size.[8] Another identifiable metabolic factor contributing to the pathogenesis of fetal macrosomia is irregularities in maternal lipids levels.[9] Other additional maternal and placental factors that influence the amount of nutrients that the fetus is exposed to include maternal physical activity, the size of the placenta, uteroplacental

blood flow, transplacental concentration gradient, and transfer capabilities of the placenta.[10] These factors are important to consider in pregnant women without associated diabetes.[10]

1.5 Risk factors

With respect to an appropriately dated pregnancy, the risk factors and aetiology of large for gestational age and macrosomic babies can be categorised into two big groups: fetal genetic factors and maternal factors.[11] The fetal genetic risk factors include constitutional factors such as familial traits, male sex and gender, race and ethnicity, large placenta in early pregnancy, and genetic variants and syndromes.[3] Numerous genetic disorders are categorised by early enhanced fetal growth and subsequently birthing larger for gestational age new-borns.[12] Some of these include Beckwith-Wiedemann syndrome, Berardinelli lipodystrophy, Simpson-Golabi-Behmel syndrome, Weaver syndrome and Sotos syndrome.[12]

One of the largest contributing maternal risk factors is maternal diabetes, whether gestational or pregestational, particularly when maternal glycaemic levels are inadequately controlled.[13] A second contributing maternal risk factor is maternal pre-pregnancy weight. The chances of a mother birthing a larger for gestational age new-born rises in a proportional pattern as pre-pregnancy maternal weight rises.[14] This association is autonomous to the increased incidence of gestational diabetes seen in obese mothers.[14,15] Disproportionate maternal weight gain throughout pregnancy is another strong contributing risk factor to birthing a larger infant.[15] In a study evaluating the relationship between weight gain in pregnancy and adverse pregnancy outcomes among women with a normal pre-pregnancy body mass index, it was found that women with a normal pre-pregnancy body mass index who gained more than 16 kg had an almost 2.5 times greater risk of giving birth to a larger for gestational age new-born compared with mothers who gained between 11kg and 16kg.[16]

Some additional risk factors that have been noted to be related to birthing larger infants include advanced maternal age, multiparity, post-term pregnancy, maternal birth weight greater than 4000g and birth of a previous large for gestational age or macrosomic new-born.[3]

1.6 Significance

There is a great risk of mortality and morbidity for both mother and baby when delivering large for gestational age and macrosomic babies. The risk of adverse and undesired outcomes, labour abnormalities and new-born complications increase based on the amount of macrosomia,

especially with birth weights of 4000 to 4499g.[3,17] Once the birth weight exceeds 5000g, the probability of stillbirth and neonatal mortality increases.[17]

The significance of large for gestational age infants when analysing the mortality and morbidity complications, can be categorised into maternal complications, fetal complications, new-born complications and childhood and beyond. Maternal complications include protracted labour, arrested labour, assisted vaginal delivery, genital tract lacerations either to the vagina, anus or rectum, postpartum haemorrhage, caesarean section delivery and uterine rupture which could lead to both mother and fetal mortality.[18,19,20]

In terms of fetal complications, this includes shoulder dystocia resulting in birth traumas such as brachial plexus injuries, fractures or in the worst case, asphyxia.[19,20] This is the most common serious intrapartum concern, and as previously mentioned, in utero larger babies are at risk of stillbirth.[19,20] The neonatal complications include hypoglycaemia, respiratory problems, polycythaemia, minor congenital anomalies, and increased frequency of admission to a neonatal intensive care unit, and these admissions may be prolonged for more than three days.[21] When looking at childhood and beyond, the most common complications recorded are obesity, impaired glucose tolerance and metabolic syndromes.[22]

1.7 Diagnosis during the antenatal period

Currently, the accuracy of different methods of evaluating fetal weight in utero has significant extrapolative errors, these methods include physical examination with Leopold manoeuvres by a trained clinician, individual assessment of clinical risk factors, maternal self-estimation, and obstetric ultrasonography.[23] In resource-equipped settings, the gold standard method used in the diagnosis of large for gestational fetuses is a two-dimensional ultrasound examination by a trained clinician.[24] Generally, during obstetric ultrasonography, Hadlock's formula which incorporates the head circumference, femur length and abdominal circumference of the fetus has been proven to be more reliable when assessing fetal weight.[24] Additionally, during ultrasonography techniques that may assist in a more accurate diagnosis of fetal weight include soft tissue measurements of the subcutaneous fat of the abdominal wall, mid-humerus, thigh, shoulder, and peri-buccal area.[24] Fetal growth charts can be used as an adjunct to ultrasound biometry to identify, monitor and manage excessive fetal growth.[25] Prior to recent years, the fetal growth charts available used reference ranges that were principally derived from single populations of industrial countries.[25] Therefore, The World Health Organisation established new fetal growth charts for international use, for populations in Africa, South America, Asia,

and Europe.[25] The limitations of standard growth curves are they rely on population-based references, rather than customised to that particular individual and fetus.[26,27] Consecutive fetal weight assessments can be done over time to generate an individual growth curve specific to an individual fetus, enhancing diagnostic accuracy; however, this is not cost-effective, especially in resource-poor countries.[26,27]

2. AIMS AND RESEARCH PROBLEM

In developing countries, such as those in sub-Saharan Africa, there has been an increase in mothers delivering large for gestational age new-borns.[28] The incidence of fetal macrosomia in developing countries has risen by 15–25% over the last few decades.[28] It is a great public health concern due to the increased morbidity and mortality for both mother and baby.[28] Although the incidence is on the rise, there is still limited research on this topic. A few studies have been published across Africa, in Ethiopia and in Tanzania.[6,29] My study aims to describe the prevalence and identify the related risk factors and pregnancy outcomes associated with delivering large for gestational age newborns in the region of Johannesburg, in The Gauteng Province of South Africa. I also hope that the information gained from this study can be used to advance maternal and perinatal health outcomes in the region of Gauteng.

3. STUDY OBJECTIVES

a. Describe the prevalence of large for gestational age new-borns in term pregnancies delivered at Chris Hani Baragwanath Academic Hospital (CHBAH) during a period from the 1st of October 2020 to the 31st of March 2021.
b. Describe the associated risk factors found in mothers who gave birth to large for gestational age new-borns during the study period.
c. Describe the pregnancy outcomes, both maternal and neonatal, found in these pregnancies during the study period.

4. METHODOLOGY

a. **Design**: Retrospective, institution-based cross-sectional study.

b. **Site of study**: Chris Hani Baragwanath Academic Hospital, in the Obstetric Department area. CHBAH is an academic and tertiary hospital located in Soweto, in Johannesburg, South Africa.[30] It is the largest hospital in Africa and the third largest hospital in the world and performs between 20 000 to 25 000 deliveries per annum.[30,31] It has a highly specialized Obstetric unit that caters to high-risk maternity patients, with specialised clinics for mothers with diabetes, other endocrine disorders, cardiac disorders, auto-immune disorders, multiple pregnancies, poor obstetric histories, HIV, HIV- related disorders and more.[32]

c. **Study population:** All women who delivered a large for gestational age singleton new-born from a term pregnancy at CHBAH between the 1st of October 2020 to the 31st of March 2021 to be included.

d. **Sample size:** The researcher expects a sample size between 150 to 200 patients.

e. **Sample criteria:**

i. **Inclusion criteria:** All women who delivered a large for gestational age singleton new-born from a term pregnancy during the study period. Large for gestational age in this study will be defined as a birth weight equal to or greater than the 90th percentile for a given gestational age, using birth weight percentile references from INTERGROWTH-21st resources, see Table 1 for boys and Table 2 for girls.[33] A term pregnancy for this study will include deliveries occurring from early term and beyond: from 37 0/7 weeks of gestation through to 42 0/7 weeks.

ii. **Exclusion criteria:** Extra-uterine pregnancies and multiple pregnancies.

f. **Data collection**:

i. This will be a retrospective, institution-based cross-sectional study of all mothers who delivered a large for gestational age singleton new-born from a term pregnancy, at CHBAH, from the 1st of October 2020 to the 31st of March 2021.

ii. A retrospective review of all the birth registers including those for normal vaginal delivery and those for caesarean delivery will be done for all births during the study period. These birth registers are kept in the labour ward, and they document every delivery performed in the department. Mothers who delivered LGA new-borns will be identified from these birth registers, and their respective hospital numbers will be noted. These mothers will then be included in the study and their relevant patient

records will be identified using their hospital numbers and reviewed in the records department. Additionally, during review of all the birth records, the total number of deliveries over the study period will also be identified, to determine the prevalence of LGA births over the study period.

iii. All the relevant data from the maternity records of each patient included in the study, found in each maternity file and case records will be collected.

iv. Only relevant immediate neonatal data available from the maternity records will be collected; specifically, the birth weight, gender, birth apgars and outcomes, need for resuscitation and whether the baby required admission.

v. The gestational age at the time of delivery will be estimated based on either the mother's last normal menstrual period (LNMP), ultrasound reports or the most reliable earliest symphysis to fundal height measurement, using maternity chart reviews. The determination of the gestational age will be based on the most accurate methods available in the maternity records, in order of the classifications of gestational age levels developed by the Global Alignment of Immunization safety Assessment (GAIA) in pregnancy, see table 3.[34] As outlined by the GAIA gestational age levels, the ACOG gestational age calculator will be used when combining gestational ages from last menstrual periods with those extrapolated from ultrasonography.

vi. All data collected; including demographics, obstetric factors, medical factors, maternal and neonatal-related factors, and the pregnancy outcomes of all the deliveries included in the study will be recorded in the format of a data sheet, see Appendix 1.

vii. Once data analysis is complete, data will be safely retained.

g. Tools: A data sheet (Appendix 1) will be used to collate the data into RedCAP.

5. DATA ANALYSIS

The information gathered on the data collection sheet will then be captured by myself and data analysis will be done with the help of a biostatistician. All data will be collected and captured in RedCAP. Categorical variables will be plotted as frequencies and percentages. Continuous variables will be plotted with standard deviations means and medians.

Variables of the study:

a. Dependent variable: large for gestational age.
b. Independent variables: maternal age, ethnicity, social habits, parity, gestational age, obstetric history, maternal past medical history, medical illnesses during pregnancy, previous large for gestational age new-born, birth weight, sex of new-born, maternal outcomes, and neonatal outcomes.

6. ETHICS AND PERMISSIONS

Prior to commencing this study, ethics approval will be requested from The University of The Witwatersrand Human Research Ethics Committee (HREC) (Medical) for a retrospective review of data, analysis, and publication.
Institutional permission to conduct the study will be sought from the Chief Executive Officer of CHBAH and the Head of Department of the Obstetrics and Gynaecology unit at CHBAH. The study will be registered with the National Health Research Database.

Each patient will be assigned a Study ID, which will be used to record their demographic and clinical data derived from the maternity record. A separate database will be kept linking the patients' Study ID, with their actual hospital number. Only myself and my supervisors will have access to this separate database, thereby ensuring patient anonymity throughout the study.

7. TIMING

The study will be a retrospective analysis.

a. Research protocol submission will be finalised in July 2021, based on the protocol submission dates outlined by the department.
b. Ethics application will be made in August 2021, based on the ethics submission dates outlined by The Witwatersrand Human HREC.
c. Data will be collected over four months from October 2021 to January 2022.
d. Data analysis will be performed in February 2022 and March 2022.
e. The final write-up will be done from April 2022 to May 2022.

	APR 2021	MAY 2021	JUN 2021	JUL 2021	AUG 2021	SEP 2021	OCT 2021	NOV 2021	DEC 2021	JAN 2022	FEB 2022	MAR 2022	APR 2022	MAY 2022
Literature Review														
Preparing Protocol														
Protocol Assessment														
Ethics Application														
Collecting Data														
Data Analysis														
Writing up-Thesis														
Writing up-Paper														

8. FUNDING

All funding costs will be borne by the researcher. The proposed budget:

Photocopying	ZAR 2 000.00
Transport	ZAR 500.00
Statistician consulting fee	ZAR 3 000.00
Presentation at a conference	ZAR 6 500.00
Publishing	ZAR 8 000.00
TOTAL	**ZAR 20 000.00**

9. LIMITATIONS

a. Being a retrospective study, the study relies on the maternity case records and files to be adequately filled in. Patient records may have incomplete data recorded in their files; therefore, the data base may be incomplete.
b. Patient records from the records department may be lost or unavailable.

10. INTENTION TO DISSEMINATE

A copy of the final write-up will be disseminated to the University of the Witwatersrand and the College of Obstetrics and Gynaecology of South Africa. The study will be registered with the National Health Research Database. There is also an intention to publish the research in medical journals and present the research at academic meetings.

11. CONFLICT OF INTEREST

No conflict of interest is anticipated.

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Appendix 2: DATA COLLECTION SHEET

Maternal and Characteristics

Maternal Socio-Demographic Characteristics					
1. Allocated study ID					
2. Age					
3. Ethnicity	BLACK	WHITE	INDIAN	COLOURED	UNKNOWN
4. Marital status	SINGLE	MARRIED	STABLE RELATIONSHIP		UNKNOWN
Maternal Clinical Characteristics					
5. Parity					
6. Gravidity					
7. Booked	YES		NO		
8. Booking date					
9. Booking gestational age					
10. Maternal weight at booking (kilograms)					
11. Height (metres)					
12. Total antenatal visits					
13. HIV status	NEGATIVE	POSITIVE	UNKNOWN		
If HIV positive, specify:					
13.1 **CD4 count**					
13.2 **Viral load**					
13.3 **Type of treatment**					
13.4 **Duration of treatment**					
14. Formal HB at booking (g/dL)					
15. RPR	NEGATIVE	POSITIVE	UNKNOWN		
15.1 **If RPR is positive:**	TREATED	NOT TREATED			
16. RH	POSITIVE	NEGATIVE			
16.1 **If RH negative**	NO ANTIBODIES PRESENT	ANTIBODIES PRESENT	ANTIBODIES UNKNOWN		

Neonatal Delivery Characteristics

17. Delivery date		
18. Baby's birth weight (kilograms)		
19. Gestational age at delivery		
20. Mode of calculating gestational age (GAIA classification level)		
21. Baby's gender	MALE	FEMALE

Analysis of Maternal Risk Factors

22. Maternal weight at delivery (kilograms)				
23. Maternal BMI at booking (kg/m^2)				
24. Maternal BMI at delivery (kg/m^2)				
25. Maternal medical conditions during pregnancy (pregnancy included in the study)	YES		NO	
If yes, please tick if present:				
25.1 **Overt diabetes**	TYPE I		TYPE II	
25.2 **Gestational diabetes**				
25.3 **Hypertensive disorders**				
25.4 **Cardiac disease**				
25.5 **Others, specify:**				
26. Previous large for gestational age baby	YES		NO	
23.1 Outcome	ALIVE	STILLBIRTH	NND	UNKNOWN
27. Previous stillbirth	YES	NO	UNKNOWN	
24.1 Gestational age at the time of stillbirth				

28. Maternal past medical history	YES		NO
If yes:			
28.1 **Gestational diabetes**	YES		NO
28.2 **Hypertensive disorders in pregnancy**	YES		NO
28.3 **If Other, specify:**			
29. Cigarette smoking	YES	NO	UNKNOWN
30. Alcohol use	YES	NO	UNKNOWN
31. Other illicit drug use	YES	NO	UNKNOWN
31.1 **If yes, specify the type of drug**			

Delivery Details of Pregnancy

32. Spontaneous labour	YES	NO
33. Induction of labour	YES	NO
34. Assisted vaginal delivery	YES	NO
34.1 **If yes, indication:**		
34.2 **Specify Type:**	FORCEPS	VENTOUSE
35. Elective caesarean delivery	YES	NO
35.1 **If yes, specify Indication:**		
36. Emergency caesarean delivery	YES	NO
If yes, indication of emergency caesarean delivery, tick:		
36.1 **Big baby**		
36.2 **Fetal distress**		
36.3 **Obstructed labour**		
36.4 **Cephalopelvic disproportion**		

36.5 **Previous c/section scar**	
36.6 **Uterine rupture**	
36.7 **IF Other (specify)**	

Maternal Complications

37. Prolonged labour		
34.1 Latent phase labour that exceeds 8 hours	YES	NO
34.2 Active phase labour with cervical dilatation less than 1cm per hour	YES	NO
38. Uterine rupture	YES	NO
39. Shoulder dystocia	YES	NO
40. Perineal tear	YES	NO
40.1 **Second degree**		
40.2 **Third degree**		
40.3 **Fourth Degree**		
41. Postpartum haemorrhage	YES	NO
42. Puerperal sepsis	YES	NO
43. Critical care admission	YES	NO
43.1 **If yes, specify where:**	HIGH CARE	ICU
44. Maternal death	YES	NO
45. Length of stay, tick:		
45.1 **Less than 3 days**		
45.2 **More than 3 days**		

Neonatal Complications

46. Outcomes		
46.1 **Alive**	YES	NO
46.2 **Stillbirth**	YES	NO
46.3 **Neonatal death within 24 hours of life**	YES	NO
47. Apgar's		
47.1 **At 1 minute**		
47.2 **At 5 minutes**		
47.3 **At 10 minutes**		
48. Congenital abnormality	YES	NO
49. Resuscitation required	YES	NO
50. Admission to the neonatal ward	YES	NO
50.1 **If yes:**	NICU	GENERAL NURSERY
51. Neonatal complications	YES	NO
If yes, tick:		
51.1 **Birth trauma**		
51.2 **Birth asphyxia**		
51.3 **Respiratory distress**		
51.4 **Hypoglycemia**		
51.5 **IF Other/ specify**		

Appendix 3: INTERGROWTH-21ST BOYS NEWBORN SIZE STANDARDS

International Newborn Size Standards



Birthweight (kg)
Boys



Gestational age (weeks+days)	Centiles						
	3rd	5th	10th	50th	90th	95th	97th
33+0	1.18	1.28	1.43	1.95	2.52	2.70	2.82
33+1	1.22	1.32	1.47	1.99	2.56	2.74	2.86
33+2	1.26	1.36	1.51	2.03	2.60	2.77	2.90
33+3	1.30	1.40	1.55	2.07	2.64	2.81	2.93
33+4	1.34	1.44	1.59	2.11	2.67	2.85	2.97
33+5	1.38	1.48	1.63	2.15	2.71	2.89	3.01
33+6	1.42	1.52	1.67	2.18	2.75	2.93	3.05
34+0	1.45	1.55	1.71	2.22	2.79	2.96	3.08
34+1	1.49	1.59	1.74	2.26	2.82	3.00	3.12
34+2	1.53	1.63	1.78	2.29	2.86	3.03	3.15
34+3	1.56	1.66	1.82	2.33	2.89	3.07	3.19
34+4	1.60	1.70	1.85	2.36	2.93	3.10	3.22
34+5	1.63	1.73	1.89	2.40	2.96	3.14	3.26
34+6	1.67	1.77	1.92	2.43	3.00	3.17	3.29
35+0	1.70	1.80	1.95	2.47	3.03	3.20	3.32
35+1	1.74	1.84	1.99	2.50	3.06	3.24	3.36
35+2	1.77	1.87	2.02	2.53	3.09	3.27	3.39
35+3	1.80	1.90	2.05	2.56	3.13	3.30	3.42
35+4	1.83	1.94	2.09	2.60	3.16	3.33	3.45
35+5	1.87	1.97	2.12	2.63	3.19	3.36	3.48
35+6	1.90	2.00	2.15	2.66	3.22	3.39	3.51
36+0	1.93	2.03	2.18	2.69	3.25	3.42	3.54
36+1	1.96	2.06	2.21	2.72	3.28	3.45	3.57
36+2	1.99	2.09	2.24	2.75	3.31	3.48	3.60
36+3	2.02	2.12	2.27	2.78	3.34	3.51	3.63
36+4	2.05	2.15	2.30	2.81	3.37	3.54	3.66
36+5	2.08	2.18	2.33	2.84	3.39	3.57	3.69
36+6	2.11	2.21	2.36	2.86	3.42	3.60	3.72
37+0	2.13	2.24	2.38	2.89	3.45	3.62	3.74
37+1	2.16	2.26	2.41	2.92	3.48	3.65	3.77
37+2	2.19	2.29	2.44	2.95	3.50	3.68	3.80
37+3	2.22	2.32	2.47	2.97	3.53	3.70	3.82
37+4	2.24	2.34	2.49	3.00	3.55	3.73	3.85
37+5	2.27	2.37	2.52	3.02	3.58	3.75	3.87
37+6	2.29	2.39	2.54	3.05	3.61	3.78	3.90

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International Newborn Size Standards

UNIVERSITY OF OXFORD

Birthweight (kg)
Boys

INTERGROWTH-21st



Gestational age (weeks+days)	Centiles						
	3rd	5th	10th	50th	90th	95th	97th
38+0	2.32	2.42	2.57	3.07	3.63	3.80	3.92
38+1	2.34	2.44	2.59	3.10	3.65	3.83	3.95
38+2	2.37	2.47	2.62	3.12	3.68	3.85	3.97
38+3	2.39	2.49	2.64	3.15	3.70	3.87	3.99
38+4	2.42	2.52	2.67	3.17	3.72	3.90	4.02
38+5	2.44	2.54	2.69	3.19	3.75	3.92	4.04
38+6	2.46	2.56	2.71	3.22	3.77	3.94	4.06
39+0	2.49	2.59	2.73	3.24	3.79	3.96	4.08
39+1	2.51	2.61	2.76	3.26	3.81	3.99	4.10
39+2	2.53	2.63	2.78	3.28	3.83	4.01	4.12
39+3	2.55	2.65	2.80	3.30	3.86	4.03	4.15
39+4	2.57	2.67	2.82	3.32	3.88	4.05	4.17
39+5	2.59	2.69	2.84	3.34	3.90	4.07	4.19
39+6	2.61	2.71	2.86	3.36	3.92	4.09	4.21
40+0	2.63	2.73	2.88	3.38	3.94	4.11	4.22
40+1	2.65	2.75	2.90	3.40	3.95	4.13	4.24
40+2	2.67	2.77	2.92	3.42	3.97	4.15	4.26
40+3	2.69	2.79	2.94	3.44	3.99	4.16	4.28
40+4	2.71	2.81	2.96	3.46	4.01	4.18	4.30
40+5	2.73	2.83	2.98	3.48	4.03	4.20	4.32
40+6	2.75	2.85	2.99	3.49	4.04	4.22	4.33
41+0	2.76	2.86	3.01	3.51	4.06	4.23	4.35
41+1	2.78	2.88	3.03	3.53	4.08	4.25	4.37
41+2	2.80	2.90	3.05	3.55	4.09	4.27	4.38
41+3	2.82	2.91	3.06	3.56	4.11	4.28	4.40
41+4	2.83	2.93	3.08	3.58	4.13	4.30	4.42
41+5	2.85	2.95	3.09	3.59	4.14	4.31	4.43
41+6	2.86	2.96	3.11	3.61	4.16	4.33	4.45
42+0	2.88	2.98	3.12	3.62	4.17	4.34	4.46
42+1	2.89	2.99	3.14	3.64	4.19	4.36	4.47
42+2	2.91	3.01	3.15	3.65	4.20	4.37	4.49
42+3	2.92	3.02	3.17	3.67	4.21	4.39	4.50
42+4	2.94	3.04	3.18	3.68	4.23	4.40	4.52
42+5	2.95	3.05	3.20	3.69	4.24	4.41	4.53
42+6	2.96	3.06	3.21	3.71	4.25	4.43	4.54

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Appendix 4: INTERGROWTH-21ST GIRLS NEWBORN SIZE STANDARDS

International Newborn Size Standards

UNIVERSITY OF OXFORD

Birthweight (kg) Girls

INTERGROWTH-21st



Gestational age (weeks+days)	Centiles						
	3rd	5th	10th	50th	90th	95th	97th
33+0	1.20	1.29	1.41	1.86	2.35	2.51	2.61
33+1	1.24	1.33	1.45	1.90	2.40	2.55	2.66
33+2	1.28	1.37	1.49	1.94	2.44	2.59	2.70
33+3	1.32	1.40	1.53	1.98	2.48	2.63	2.74
33+4	1.36	1.44	1.57	2.02	2.52	2.67	2.78
33+5	1.39	1.48	1.61	2.06	2.56	2.72	2.82
33+6	1.43	1.52	1.65	2.09	2.60	2.75	2.86
34+0	1.47	1.55	1.68	2.13	2.64	2.79	2.90
34+1	1.50	1.59	1.72	2.17	2.67	2.83	2.94
34+2	1.54	1.62	1.75	2.20	2.71	2.87	2.98
34+3	1.57	1.66	1.79	2.24	2.75	2.91	3.01
34+4	1.61	1.69	1.82	2.28	2.79	2.94	3.05
34+5	1.64	1.73	1.86	2.31	2.82	2.98	3.09
34+6	1.67	1.76	1.89	2.35	2.86	3.02	3.12
35+0	1.71	1.79	1.92	2.38	2.89	3.05	3.16
35+1	1.74	1.83	1.96	2.41	2.93	3.09	3.19
35+2	1.77	1.86	1.99	2.45	2.96	3.12	3.23
35+3	1.80	1.89	2.02	2.48	2.99	3.15	3.26
35+4	1.83	1.92	2.05	2.51	3.03	3.19	3.30
35+5	1.86	1.95	2.08	2.54	3.06	3.22	3.33
35+6	1.89	1.98	2.11	2.57	3.09	3.25	3.36
36+0	1.92	2.01	2.14	2.60	3.12	3.28	3.39
36+1	1.95	2.04	2.17	2.63	3.15	3.31	3.42
36+2	1.98	2.07	2.20	2.66	3.18	3.34	3.45
36+3	2.00	2.09	2.23	2.69	3.21	3.37	3.48
36+4	2.03	2.12	2.25	2.72	3.24	3.40	3.51
36+5	2.06	2.15	2.28	2.75	3.27	3.43	3.54
36+6	2.08	2.17	2.31	2.77	3.30	3.46	3.57
37+0	2.11	2.20	2.33	2.80	3.32	3.49	3.60
37+1	2.14	2.23	2.36	2.83	3.35	3.52	3.63
37+2	2.16	2.25	2.38	2.85	3.38	3.54	3.65
37+3	2.18	2.27	2.41	2.88	3.40	3.57	3.68
37+4	2.21	2.30	2.43	2.90	3.43	3.60	3.71
37+5	2.23	2.32	2.46	2.93	3.46	3.62	3.73
37+6	2.25	2.35	2.48	2.95	3.48	3.65	3.76

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International Newborn Size Standards

UNIVERSITY OF OXFORD

Birthweight (kg)
Girls

INTERGROWTH-21st



Gestational age (weeks+days)	Centiles						
	3rd	5th	10th	50th	90th	95th	97th
38+0	2.28	2.37	2.50	2.97	3.51	3.67	3.78
38+1	2.30	2.39	2.53	3.00	3.53	3.69	3.81
38+2	2.32	2.41	2.55	3.02	3.55	3.72	3.83
38+3	2.34	2.43	2.57	3.04	3.58	3.74	3.85
38+4	2.36	2.45	2.59	3.06	3.60	3.76	3.88
38+5	2.38	2.47	2.61	3.09	3.62	3.79	3.90
38+6	2.40	2.50	2.63	3.11	3.64	3.81	3.92
39+0	2.42	2.51	2.65	3.13	3.66	3.83	3.94
39+1	2.44	2.53	2.67	3.15	3.68	3.85	3.96
39+2	2.46	2.55	2.69	3.17	3.70	3.87	3.99
39+3	2.48	2.57	2.71	3.19	3.72	3.89	4.01
39+4	2.50	2.59	2.73	3.21	3.74	3.91	4.03
39+5	2.51	2.61	2.74	3.22	3.76	3.93	4.04
39+6	2.53	2.62	2.76	3.24	3.78	3.95	4.06
40+0	2.55	2.64	2.78	3.26	3.80	3.97	4.08
40+1	2.56	2.66	2.80	3.28	3.82	3.99	4.10
40+2	2.58	2.67	2.81	3.29	3.84	4.00	4.12
40+3	2.60	2.69	2.83	3.31	3.85	4.02	4.14
40+4	2.61	2.70	2.84	3.33	3.87	4.04	4.15
40+5	2.63	2.72	2.86	3.34	3.89	4.05	4.17
40+6	2.64	2.73	2.87	3.36	3.90	4.07	4.19
41+0	2.65	2.75	2.89	3.37	3.92	4.09	4.20
41+1	2.67	2.76	2.90	3.39	3.93	4.10	4.22
41+2	2.68	2.77	2.91	3.40	3.95	4.12	4.23
41+3	2.69	2.79	2.93	3.41	3.96	4.13	4.25
41+4	2.71	2.80	2.94	3.43	3.97	4.15	4.26
41+5	2.72	2.81	2.95	3.44	3.99	4.16	4.27
41+6	2.73	2.82	2.96	3.45	4.00	4.17	4.29
42+0	2.74	2.84	2.98	3.46	4.01	4.19	4.30
42+1	2.75	2.85	2.99	3.48	4.03	4.20	4.31
42+2	2.76	2.86	3.00	3.49	4.04	4.21	4.33
42+3	2.77	2.87	3.01	3.50	4.05	4.22	4.34
42+4	2.78	2.88	3.02	3.51	4.06	4.23	4.35
42+5	2.79	2.89	3.03	3.52	4.07	4.24	4.36
42+6	2.80	2.90	3.04	3.53	4.08	4.26	4.37

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Villar et al. *Lancet* 2014;384:857-68

Appendix 5: GAIA TABLE

A classification of gestational age levels developed by the Global Alignment of Immunization Safety Assessment in Pregnancy

Assessment of Gestational Age	
GAIA Level 1	a) the last menstrual period or intrauterine insemination date or embryo transfer date with confirmatory first-trimester scan (less than or equal to 13 6/7 weeks) OR b) first-trimester scan (less than or equal to 13 6/7 weeks).
GAIA Level 2a	a) Certain last menstrual period date with second-trimester scan (14 0/7 weeks to 27 6/7 weeks), (If last menstrual period and ultrasound do not correlate, default to ultrasound gestational age assessment) OR b) Certain last menstrual period dates with first-trimester physical examination
GAIA Level 2b	Uncertain last menstrual period date with second-trimester scan (14 0/7 weeks to 27 6/7 weeks).
GAIA Level 3a	a) Certain last menstrual period date with third-trimester scan (28 0/7 weeks or more) OR b) Certain last menstrual period date with confirmatory second-trimester fundal height OR c) Certain last menstrual period date with birth weight OR d) Uncertain last menstrual period date with first-trimester physical examination
GAIA Level 3b	a) Uncertain last menstrual period date with fundal height OR b) Uncertain last menstrual period date with new-born physical assessment OR c) Uncertain last menstrual period date with birth weight.

Appendix 6: POSTGRADUATE APPROVAL OF TITLE LETTER

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

02 December 2021
Person No: 300191
PAG

Dr NM Chibaya
16 Shipston Road
Greystone Park
0
Zimbabwe

Dear Dr Natsai Chibaya

Master of Medicine in Obstetrics and Gynaecology: Approval of Title

We have pleasure in advising that your proposal entitled *The prevalence, associated risk factors and pregnancy related outcomes of large for gestational age new-borns delivered at Chris Hani Baragwanath Academic Hospita* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix 7: INSTITUTION PERMISSION TO CONDUCT RESEARCH

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 8 November 2021

TITLE OF PROJECT:

The Prevalence, Associated Risk Factors and Pregnancy Related Outcomes of Large for Gestational Age New-Borns Delivered at Chris Hani Baragwanath Academic Hospital.

UNIVERSITY: Witwatersrand

Principal Investigator: Dr N M Chibaya

Department: O&G

Supervisor/s : Dr C Georgiou / Odell

Permission Head Department (where research conducted): Yes

NHRD No.

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

Recommended
(On behalf of the MAC)
2021/11/08

Approved/~~Not Approved~~
Hospital Management Date:
Date: 8/11/2021

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

PERMISSION TO CONDUCT RESEARCH AT CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PRINCIPLE RESEARCHER:

Full Name:	DR NATSAI MICHELLE CHIBAYA
Designation:	OBSTETRICS AND GYNECOLOGY REGISTRAR
Contact number:	079 395 3910
Email:	nmchibaya@gmail.com
Name of supervisor:	DR CHRYSANTHI GEORGIOU
	DR NATALIE ODELL
	DR NADIYA FRANK

Title of Research:

THE PREVELANCE , ASSOCIATED RISK FACTORS AND PREGNANCY RELATED OUTCOMES OF LARGE FOR GESTATIONAL AGE NEW-BORNS DELIVERED AT CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

Study site:	OBSTETRICS DEPARTMENT/ LABOUR WARD
Expected start date:	01- 01- 2022
Expected duration:	SIX MONTHS
Ethic clearance:	PROVISIONAL CLEARANCE GRANTED ON CONDITION OF PERMISSIONS
Conflict of interest:	NO
Cost to hospital or patients:	NONE
Source of research funding:	RESEARCHER

APPROVAL BY HEAD OF DEPARTMENT OF OBSTETRICS AND GYNAECOLOGY: YES

By Professor Yasmin Adam

Signature ..... Date 16/2/2022

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

PERMISSION TO CONDUCT RESEARCH AT CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PRINCIPLE RESEARCHER:

Full Name:	DR NATSAI MICHELLE CHIBAYA
Designation:	OBSTETRICS AND GYNECOLOGY REGISTRAR
Contact number:	079 395 3910
Email:	nmchibaya@gmail.com
Name of supervisor:	DR CHRYSANTHI GEORGIOU
	DR NATALIE ODELL
	DR NADIYA FRANK

Title of Research:

THE PREVELANCE , ASSOCIATED RISK FACTORS AND PREGNANCY RELATED OUTCOMES OF LARGE FOR GESTATIONAL AGE NEW-BORNS DELIVERED AT CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

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Expected duration:	SIX MONTHS
Ethic clearance:	PROVISIONAL CLEARANCE GRANTED ON CONDITION OF PERMISSIONS
Conflict of interest:	NO
Cost to hospital or patients:	NONE
Source of research funding:	RESEARCHER

APPROVAL BY NURSING MANAGER OF OBSTETRICS AND GYNECOLOGY (MATERNITY THEATRE AND LABOUR WARD MANAGER): YES

By Matron Nomsa Ramela

Signature Ramela Date 17/02/2022

Appendix 8: ETHICS CLEARANCE CERTIFICATE

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Dr N Chibaya

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M2111119

NAME: (Principal Investigator)	Dr N Chibaya
DEPARTMENT:	School of Clinical Medicine Department of Obstetrics and Gynaecology Medical School University
PROJECT TITLE:	*The prevalence, associated risk factors and pregnancy-related outcomes of large for gestational age new-borns devivered at Chris Hani Baragwanath Academic Hospital*
DATE CONSIDERED:	2021/11/26
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Drs C Georhiou, N Odell and N Frank
APPROVED BY:	CB Penny Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2022/03/07

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **November** and therefore reports and re-certification will be due in the month of November each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

01/01/2022
Date

Appendix 9: SIMILARITY TURNITIN REPORT

Final MMED for turnit in.docx

by Natsai Chibaya

Submission date: 20-Feb-2024 07:53PM (UTC+0200)
Submission ID: 2299763183
File name: Final_MMED_for_turnit_in.docx (35.52K)
Word count: 3237
Character count: 18432

Final MMED for turnit in.docx

ORIGINALITY REPORT

10%	5%	6%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Aisha Salim Said, Karim Premji Manji. "Risk factors and outcomes of fetal macrosomia in a tertiary centre in Tanzania: a case-control study", BMC Pregnancy and Childbirth, 2016 Publication	1%
2	Submitted to Monash University Student Paper	1%
3	Submitted to University of Witwatersrand Student Paper	1%
4	Konin, Ashwini. "Study of Factors Contributing to Increasing Caesarean Delivery Rate", Rajiv Gandhi University of Health Sciences (India), 2023 Publication	1%
5	Submitted to University College London Student Paper	1%
6	afju.springeropen.com Internet Source	1%
7	scholarworks.iupui.edu Internet Source	<1%

8	www.science.gov Internet Source	<1%
9	I-Weng Yen, Shin-Yu Lin, Ming-Wei Lin, Chien-Nan Lee et al. "The association between plasma angiopoietin-like protein 4, glucose and lipid metabolism during pregnancy, placental function, and risk of delivering large-for-gestational-age neonates", Clinica Chimica Acta, 2024 Publication	<1%
10	samajournals.co.za Internet Source	<1%
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15	Varghese, Achamma. "Impact of Physical Health Status of Antenatal Mothers on their Neonates Born in a Selected Hospital", Rajiv Gandhi University of Health Sciences (India), 2023 Publication	<1%

16	www.acemap.info Internet Source	<1 %
17	www.researchsquare.com Internet Source	<1 %
18	Barak Rosenn. "Obesity and diabetes: A recipe for obstetric complications", The Journal of Maternal-Fetal & Neonatal Medicine, 2009 Publication	<1 %
19	Ling, Yeoh Ping. "Adequacy of Antenatal Care: Associated Factors and Pregnancy Outcomes among Women Attending Public Health Clinics in Selangor, Malaysia", University of Malaya (Malaysia), 2023 Publication	<1 %
20	Wang, Xuelian. "Big Data for Quality Improvement in Neonatal Clinical Care", The Chinese University of Hong Kong (Hong Kong) Publication	<1 %
21	bmcophthalmol.biomedcentral.com Internet Source	<1 %
22	www.itmedicalteam.pl Internet Source	<1 %

Appendix 10: PLAGIARISM DECLARATION

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I NATSAI MICHELLE CHIBAYA (Student number: 300191) am a student registered for the degree of MASTER OF MEDICINE in the academic year 4th (2024)

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: [signature] Date: 03 OCTOBER 2024

1